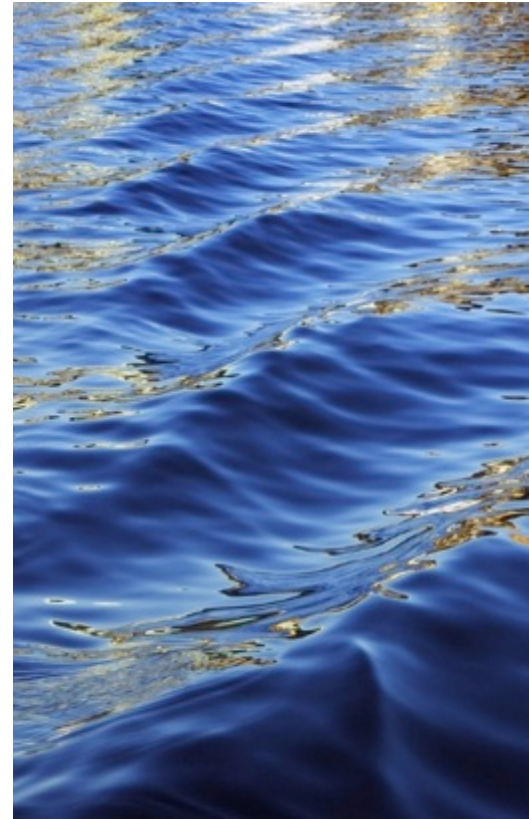
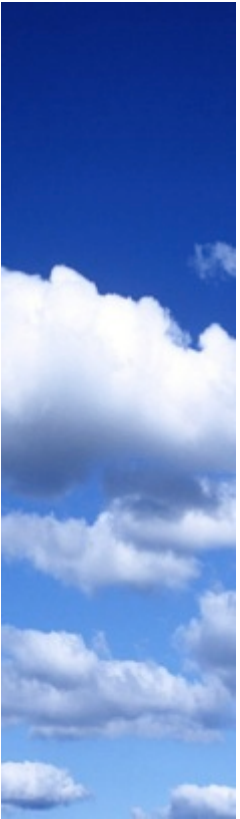


# Yale Framework

Strategies for Integrating  
Climate Adaptation Models  
Into Resource Planning

Anne M. Trainor  
Yale University

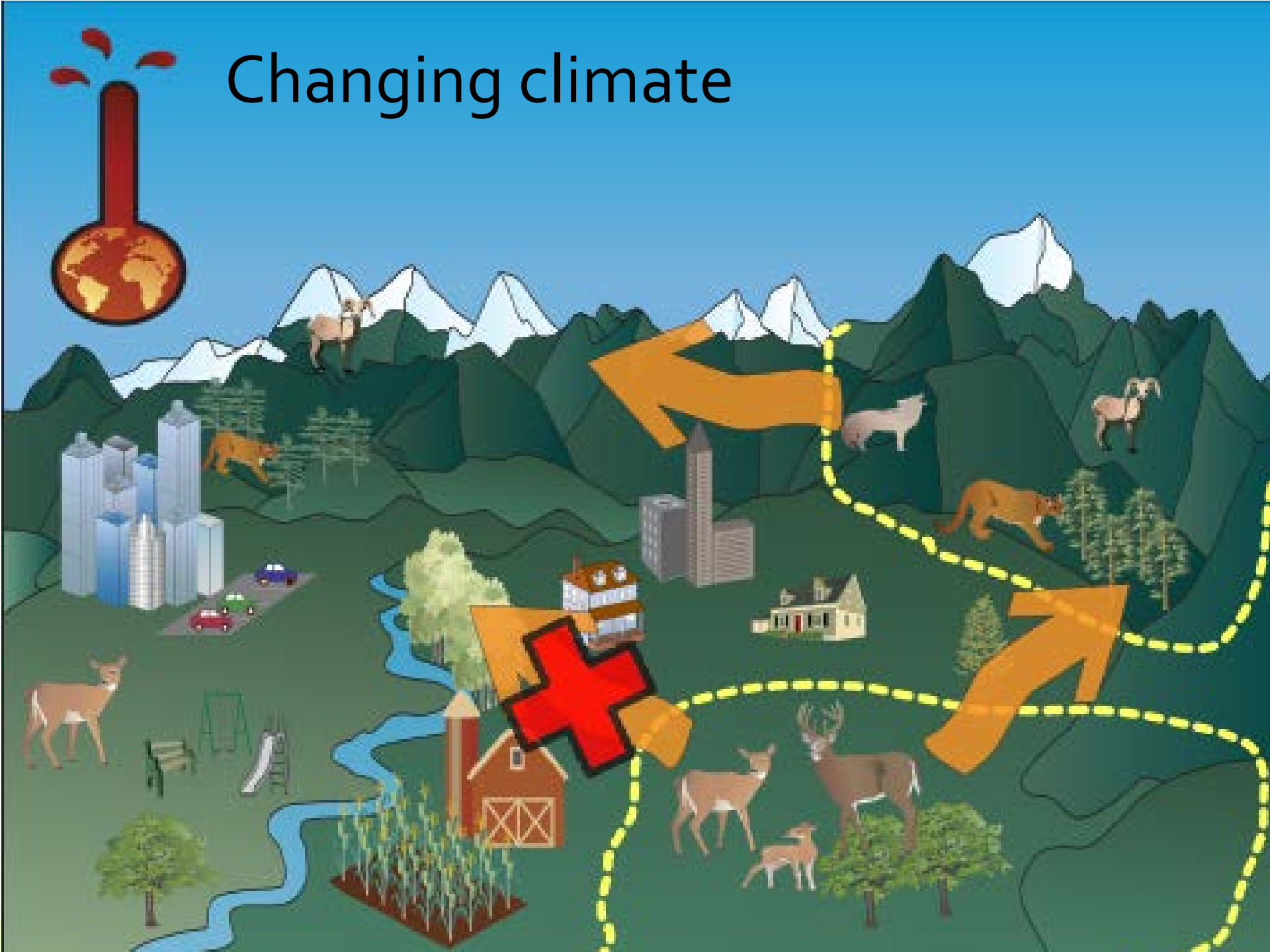




# Non-climate Stressor



# Changing climate





Review

**Biodiversity management in the face of climate change:  
A review of 22 years of recommendations**

Nicole E. Heller\*, Erika S. Zavaleta

Environmental Studies Department, University of California, Santa Cruz, Santa Cruz, CA 95606, United States

*Conservation Biology* 

---

*Review*

---

**A Review of Climate-Change Adaptation Strategies for  
Wildlife Management and Biodiversity Conservation**

JONATHAN R. MAWDSLEY,<sup>††</sup> ROBIN O'MALLEY, AND DENNISS OJIMA

The Heinz Center, 900 17th Street NW, Suite 700, Washington, D.C. 20006, U.S.A.

 **Global Change Biology**

Global Change Biology (2011) 17, 3150–3160, doi: 10.1111/j.1365-2486.2011.02457.x

**Incorporating climate change adaptation into national  
conservation assessments**

EDWARD T GAME<sup>\*†</sup>, GEOFFREY LIPSETT-MOORE<sup>\*</sup>, EARL SAXON<sup>‡</sup>, NATE PETERSON<sup>\*</sup>  
and STUART SHEPPARD<sup>§</sup>

<sup>\*</sup>The Nature Conservancy, South Brisbane, QLD 4101, Australia, <sup>†</sup>The School of Biological Sciences, University of Queensland, St Lucia, QLD 4072, Australia, <sup>‡</sup>Center for Environment, Energy and Enterprise, AED, Washington DC 20009, USA, <sup>§</sup>The Nature Conservancy, Sanur, Bali, Indonesia



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# Yale Framework

Aug 2010

- Private Funders

Doris Duke Charitable Foundation, The Kresge Foundation, & Wilburforce Foundation

Jan. 2011

- Approached Yale School of Forestry and Environmental Studies

Jan. 2011

Feb 2011 to

August 2012

- Assessment to support decision making
- Convene a panel experts





Science Panel Representation



	Federal Govt.	State Govt.	NGO	Academia
Policy & Science	✓	✓	✓	
Technology & modeling		✓	✓	✓
Conservation Biology	✓	✓	✓	✓





# Yale Framework

Aug 2010

- Private Funders

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Jan. 2011

- Approached Yale School of Forestry and Environmental Studies

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Feb 2011 to

- Assessment to support decision making

August 2012

- Convene a panel experts

Oct 2011 to

- Framework developed and refined

March 2012

- Framework was tested

Present

and evaluated

- Outreach



# Global change is requiring conservation scientists to embrace a more dynamic view of landscapes

- Spatially-explicit task
- Understand biophysical environment shaping species and ecosystem(s) spatial domains
- Develop and implement adaptation approaches to account for dynamic landscapes

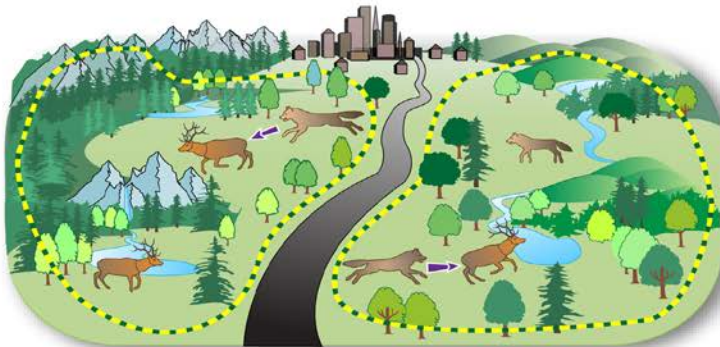


Credit: USGCRP & IPCC

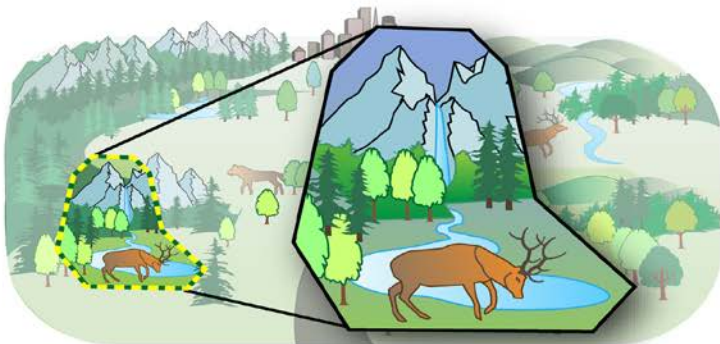
## Strengthen Current Conservation Efforts



Protect current patterns of biodiversity

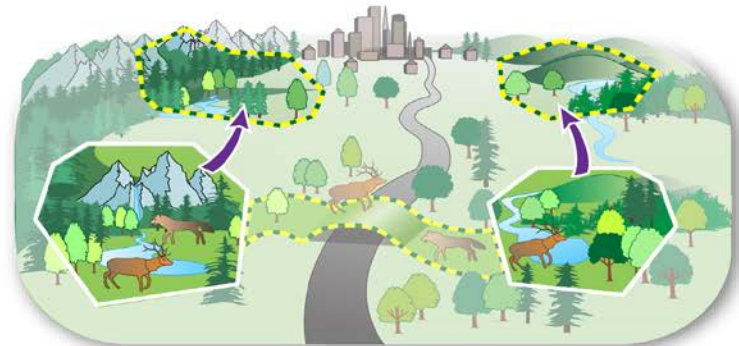


Protect large intact natural landscapes and ecological processes

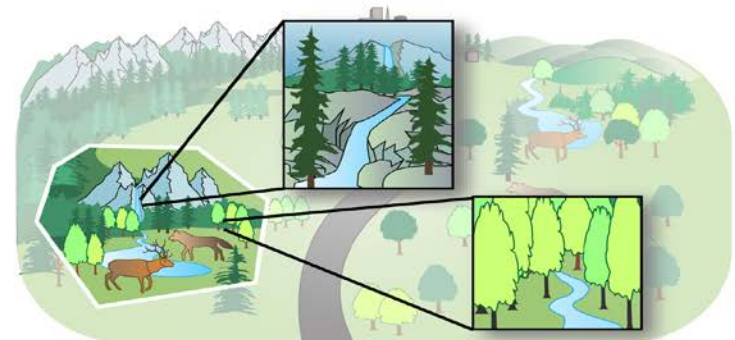


Protect the geophysical setting

## Anticipate and Respond to Future Conditions



Identify and protect future climate space



Identify and protect climate refugia

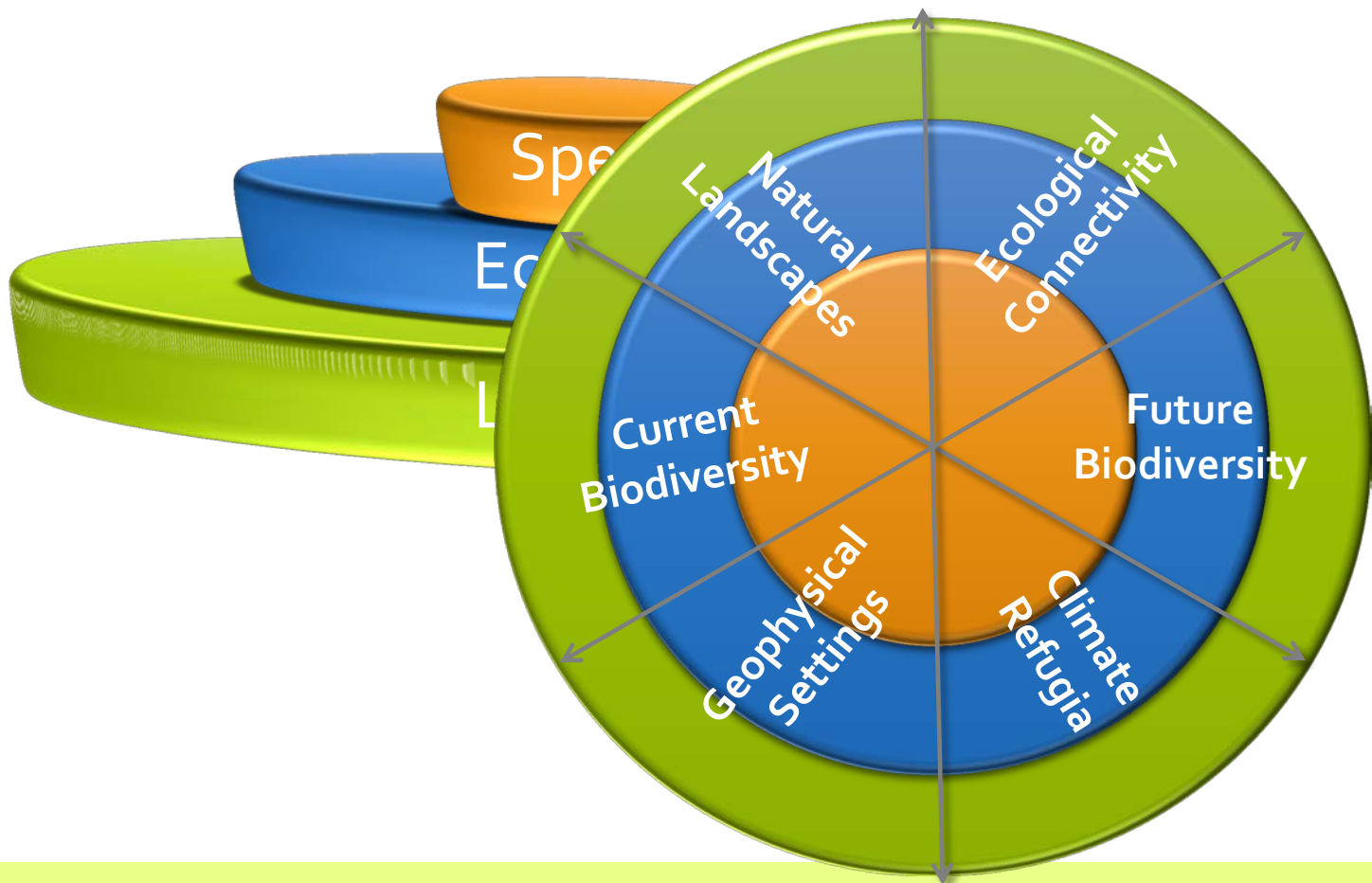


Maintain and establish ecological connectivity

Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			



Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			





## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

#### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

#### B. Anticipating and responding to

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity



## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

Assess and map  
species  
occurrences

### B. Anticipating and responding to future conditions

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity





## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

Map terrestrial and aquatic ecosystems

### B. Anticipating and responding to future conditions

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity



## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

Map genetic pattern or biodiversity hotspots

### B. Anticipating and responding to future conditions

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity





## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

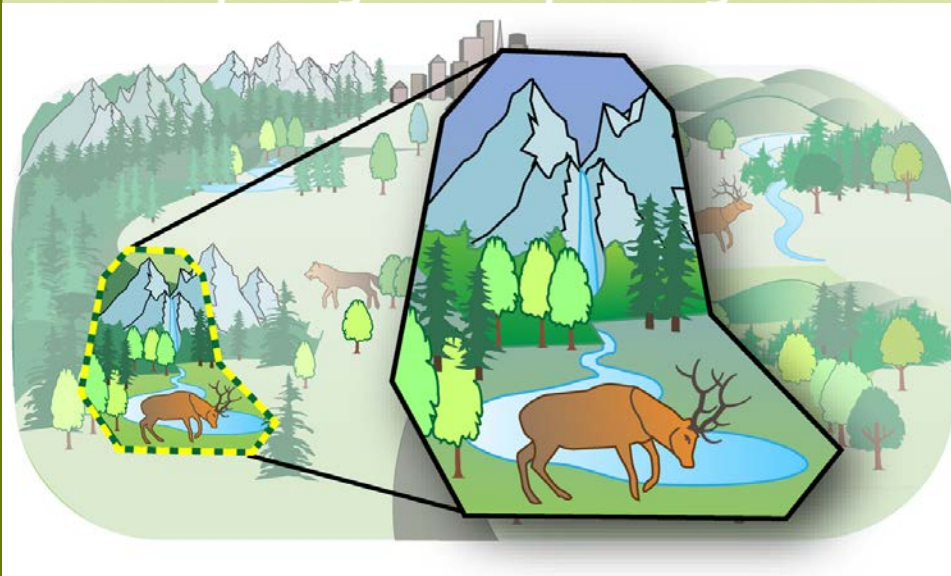
#### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

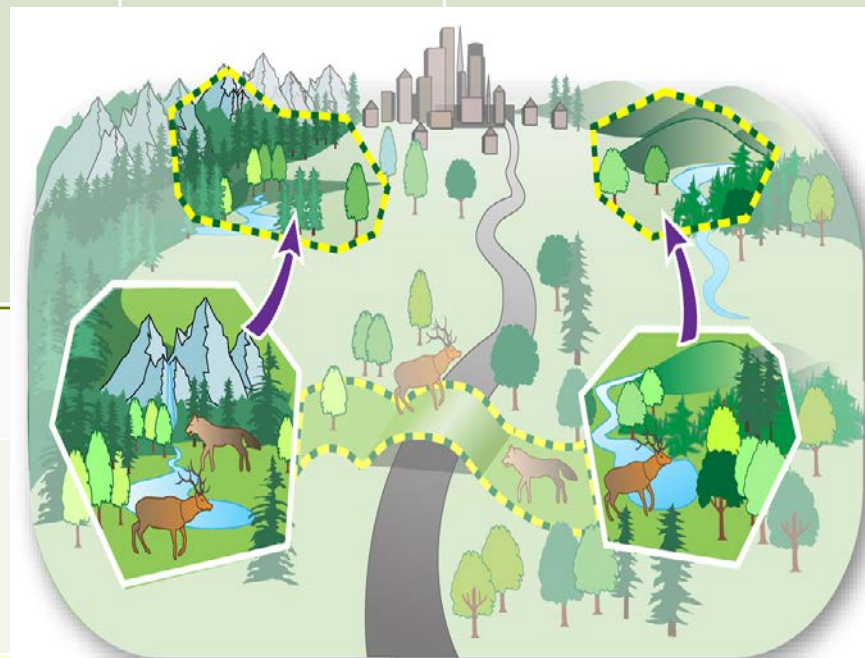
#### B. Anticipating and responding to future conditions



Map areas of high topographic complexity and substrate materials to ensure that conserved lands cover a wide range of geophysical settings

## Ecological Level

Adaptation Approach	Species & Population	Ecosystem	Landscape
<b>A. Strengthen current conservation efforts</b>			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
<b>B. Anticipating and responding to future conditions</b>			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			





## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

#### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

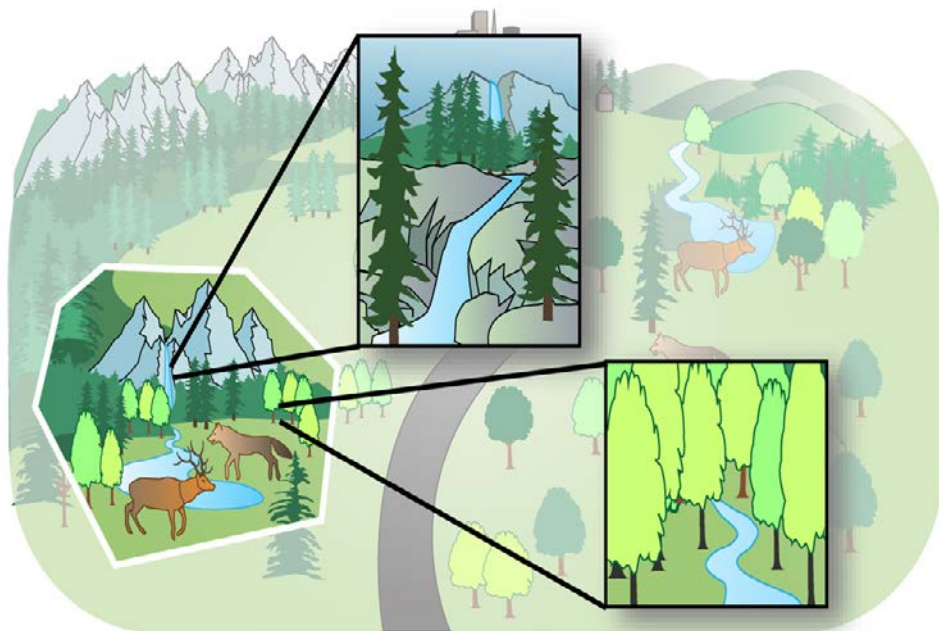
3) Protect the geophysical setting

#### B. Anticipating and responding to future conditions

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity



## Ecological Level

### Adaptation Approach

Species &  
Population

Ecosystem

Landscape

#### A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

#### B. Anticipating and responding to future conditions

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity



Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting		Forest Service	
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.		BLM, USGS	National Park Service
5) Identify and protect climate refugia		USGS	
6) Maintain and restore ecological connectivity			

# Pilot Projects

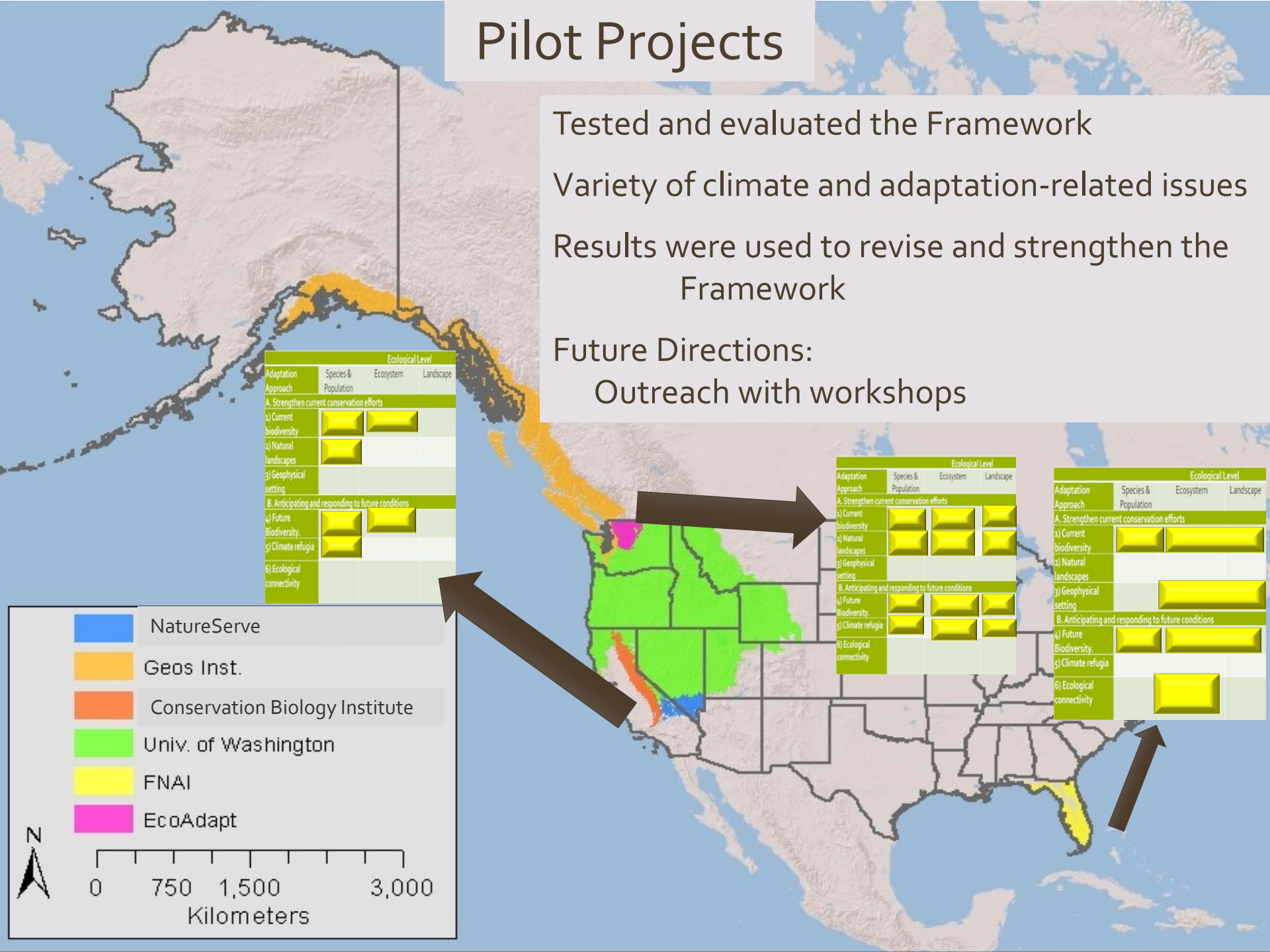
Tested and evaluated the Framework

Variety of climate and adaptation-related issues

Results were used to revise and strengthen the Framework

Future Directions:

Outreach with workshops



NatureServe

Geos Inst.

Conservation Biology Institute

Univ. of Washington

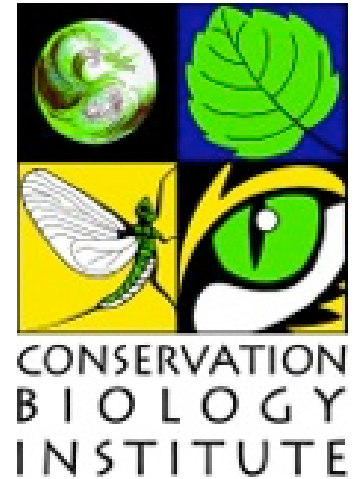
FNAI

EcoAdapt

0 750 1,500 3,000  
Kilometers

# Feedback from Pilot Projects

- Guided development of conservation for future conditions
- Compared results across ecological levels
- Highlighted gaps for future research and data collection
- Enhanced collaboration with government and private agencies





# Using Yale Mapping Framework

[yale.databasin.org](http://yale.databasin.org)

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## Yale Mapping Framework

INTEGRATING CLIMATE ADAPTATION AND LANDSCAPE CONSERVATION PLANNING

search  search by geography

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**What is the Yale Mapping Framework?**


**What is included?**

**What can I do?**

The Yale Mapping Framework includes advice and tools to assist conservation planners in selecting the assessment and modeling strategies that fit their needs.



### The Challenge



Debates about anthropogenic origins aside, scientific evidence demonstrates that the Earth's climate is changing. Many species are responding to this changing climate by shifting their geographic ranges. The differential rates at which species will shift their ranges will also result in a reshuffling of species relationships, ecological processes, and related ecosystem services.

As a result, conservation planners are now faced with the challenge of developing and implementing strategies that will support wildlife to adapt to climate change. The large number and diversity of models and data that can be applied to climate-impact analyses and adaptation strategies can often be confusing.

### The Framework

Recognizing a need for clarity within this field, the Yale School of Forestry & Environmental Studies convened a working group of the nation's leading conservation biologists, modelers, and policymakers to develop guidance for integrating climate-change adaptation strategies into the context of natural-resource planning and policymaking.

The product of this working group — The Yale Framework — assists conservation planners in selecting the assessment and modeling strategies that are most relevant to their specific needs. Rather than supplanting existing techniques, the Yale Framework provides simplified and flexible advice on models and data, and presents a list of commonly used datasets that can be helpful to planners. The Framework also provides a structured menu of options that assist resource managers in determining the best possible approach to conservation, as opposed to offering a prescriptive approach to natural resource management.

*...assists in selecting the assessment and modeling strategies that are most relevant to specific needs...*


### Data Basin and the Framework

The Yale Mapping Framework has been built using the Data Basin platform. Data Basin makes it simple to find reliable data and make compelling visualizations. Planners can locate datasets, combine multiple layers together in a visualization session, and then share maps with their colleagues. With the Data Basin data and tools, planners have everything they need to make their assessments.

### How the Framework Helps Planners


- It organizes the reasoning behind the use of specific assessment approaches.
- It helps build a better understanding of the types of questions a model can credibly address.
- It ensures greater transparency with a strong foundation of data.
- It focuses assessments on the appropriate scale and planning use.
- It can serve as a tool for policymakers to evaluate the models behind proposed land use plans.

### Recent Datasets




**Dataset**

National Land Cover Database, land cover - Alaska (north-central)




**Dataset**

National Land Cover Database, percent imperviousness - superzone five



**Dataset**

Mean annual precipitation, 2046-2095, Hadley CM3 A2, 4 km resolution




**Dataset**


Simulated vegetation carbon (g C m<sup>2</sup>), 2046-2095, Hadley CM3 A1fi, 10 km ...

[see more](#)

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THE KRESGE FOUNDATION



# Using Yale Framework

[yale.databasin.org/pages/matrix](http://yale.databasin.org/pages/matrix)

Each cell links to :

- Description of Approaches
- Tool commonly used
- Pilot Projects


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YALE MAPPING FRAMEWORK | THE FRAMEWORK MATRIX

## The Framework Matrix



The Framework Matrix is built around the consideration of six major adaptation objectives for biodiversity conservation and climate adaptation and three levels of ecological analysis. The matrix is structured to provide a systematic way to arrive at an appropriate assessment approach and related tools:

1. Select the desired adaptation objectives (row)
2. Select the desired level of ecological analyses (column)
3. Use the links in each cell of the matrix to further investigate information about the appropriate approaches one would use to carry out an assessment.

Adaptation Objectives <small>How to choose adaptation objectives</small>	Levels of Ecological Analysis <small>How to choose levels of ecological analysis</small>		
	(A) Species and Populations	(B) Ecosystems	(C) Landscape
<b>Strengthen current conservation efforts</b>			
(1) Protect current patterns of biodiversity	<b>1A Description</b>  Pilot projects: Conservation Biology Institute EcoAdapt Geos Institute NatureServe	<b>1B Description</b>  Pilot projects: Conservation Biology Institute EcoAdapt Geos Institute NatureServe	<b>1C Description</b>  Pilot projects: EcoAdapt Geos Institute
(2) Protect large, intact, natural landscapes and ecological processes	<b>2A Description</b>  Pilot projects: Geos Institute NatureServe	<b>2B Description</b>  Pilot projects: Geos Institute NatureServe	<b>2C Description</b>  Pilot projects: Geos Institute NatureServe
(3) Protect the geophysical setting		<b>3B Description</b>  Pilot projects: Geos Institute University of Washington	<b>3C Description</b>  Pilot projects: Geos Institute University of Washington
<b>Anticipate and respond to future conditions</b>			
(4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.	<b>4A Description</b>  Pilot projects: Conservation Biology Institute EcoAdapt Geos Institute NatureServe	<b>4B Description</b>  Pilot projects: Conservation Biology Institute EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe	<b>4C Description</b>  Pilot projects: EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe
(5) Identify and protect climate refugia	<b>5A Description</b>  Pilot projects: NatureServe	<b>5B Description</b>  Pilot projects: EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe	<b>5C Description</b>  Pilot projects: EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe
(6) Maintain and restore ecological connectivity	<b>6A Description</b>  Pilot projects: NatureServe	<b>6B Description</b>  Pilot projects: NatureServe	<b>6C Description</b>  Pilot projects: Geos Institute NatureServe

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# Using Yale Framework

## Selecting and developing adaptation approaches

Choose the:

1. Adaptation strategy(ies) goals.
2. Level(s) of ecological organization.
3. Analysis tool(s).
4. Data sets.
5. Assessment time horizon




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YALE MAPPING FRAMEWORK | THE FRAMEWORK MATRIX

### The Framework Matrix



The Framework Matrix is built around the consideration of six major adaptation objectives for biodiversity conservation and climate adaptation and three levels of ecological analysis. The matrix is structured to provide a systematic way to arrive at an appropriate assessment approach and related tools:

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# Evaluating the Guidance

Project Overview

Study Area/Ecosystem

Objectives

Adaptation Strategies

Full Project Analysis

Methods

Outcomes

Interpretation

Related Data

## Yale Mapping Framework

INTEGRATING CLIMATE ADAPTATION AND LANDSCAPE CONSERVATION PLANNING

Get Started

Explore

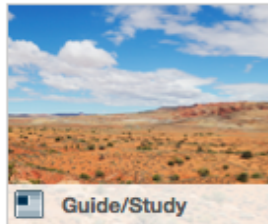
Create

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### Pilot Projects *Practical experience with the Yale Mapping Framework*

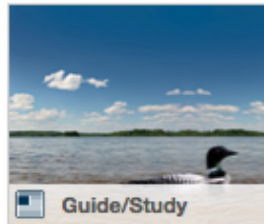
The Yale Framework will be evaluated through a process of grants to regional mapping and analysis teams that reflect the wide diversity of planning needs and challenges across the United States. These teams will use the Framework guidelines to implement geospatial analysis approaches pertinent to their respective regional planning contexts and objectives. After implementing and evaluating the Yale Framework, these teams will then provide feedback on the utility of its guidelines and the strengths and weaknesses in relation to each team's specific approach, objectives, scales, and planning timeframe. Teams will also identify improvements to the guidelines that are delineated in the Yale Framework. During this time the Science Panel will continue to refine the Framework as input from outside experts and policy makers is sought through a peer review process. Below are the guides and case studies developed by these teams.



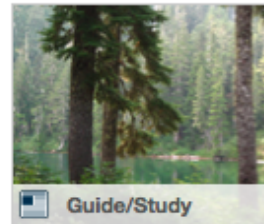
Guide/Study  
Climate Change  
Adaptation Strategies  
for BLM Resource  
Management in ...



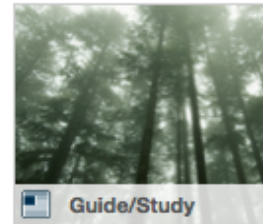
Guide/Study  
Effects of climate and  
vegetation on martens  
and fishers in the Sierra  
...



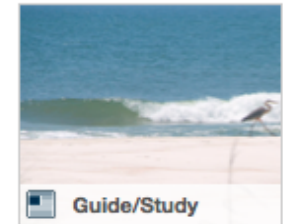
Guide/Study  
From the Mountains to  
the Sea: Applying the  
Yale Framework in  
Puget ...



Guide/Study  
Land Facets for  
Conservation Planning



Guide/Study  
Rapid Assessment of  
the Yale Framework and  
Adaptation Blueprint for  
the ...



Guide/Study  
Re-evaluating Florida's  
ecological conservation  
priorities in the face ...



# Take-home message

- Growing need to incorporate dynamic landscape
- Yale Framework
  - Building on current capacity and strengths
  - Opportunity to leverage current efforts with partnerships and collaborations



# Acknowledgements



D O R I S D U K E  
CHARITABLE FOUNDATION



THE KRESGE FOUNDATION







# Questions?

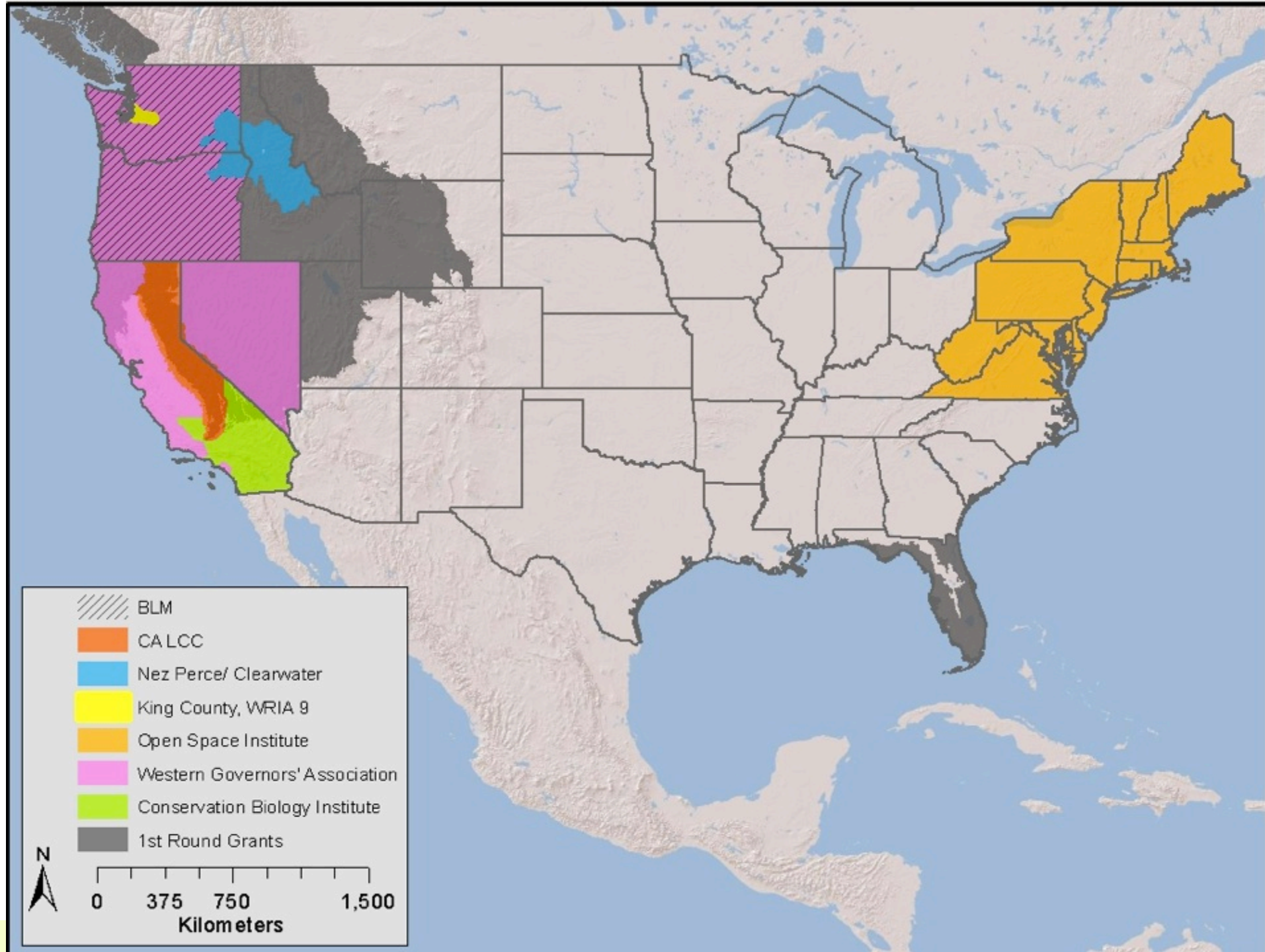
[yale.databasin.org](http://yale.databasin.org)

[Anne.Trainor@yale.edu](mailto:Anne.Trainor@yale.edu)



**STRATEGIES *for* INTEGRATING  
CLIMATE ADAPTATION MODELS  
*into* RESOURCE PLANNING**





# Pilot Projects

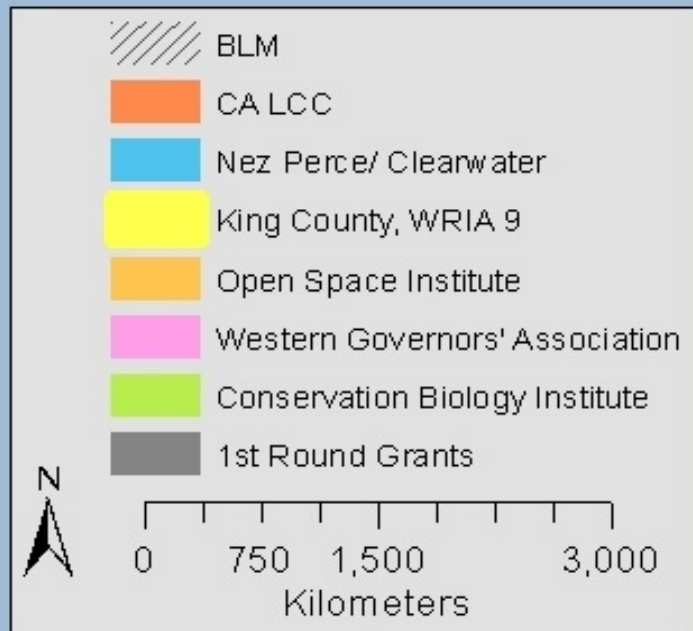
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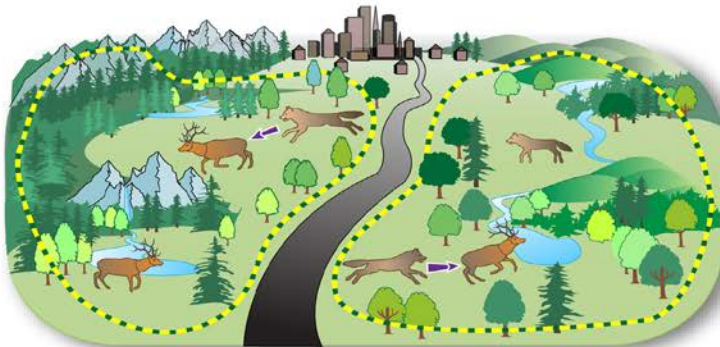




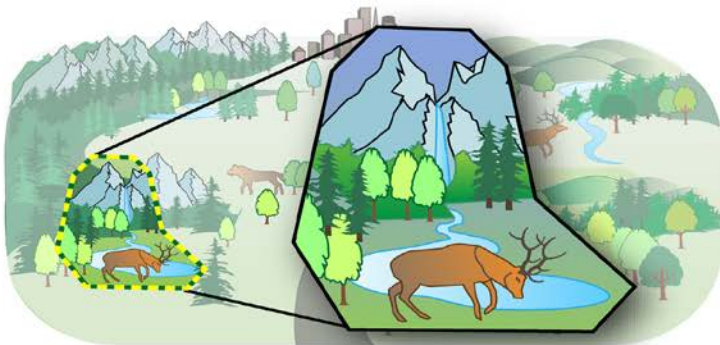
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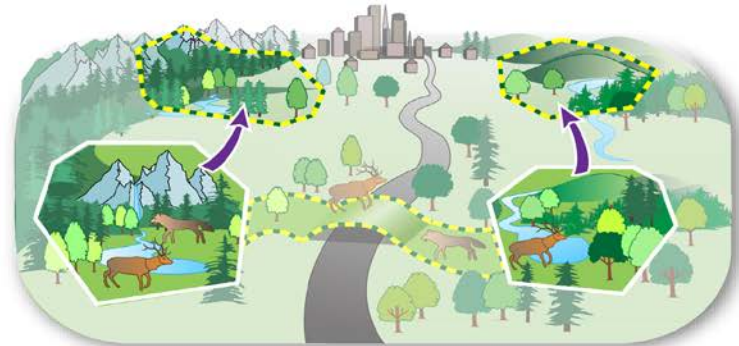


Protect large intact natural landscapes and ecological processes

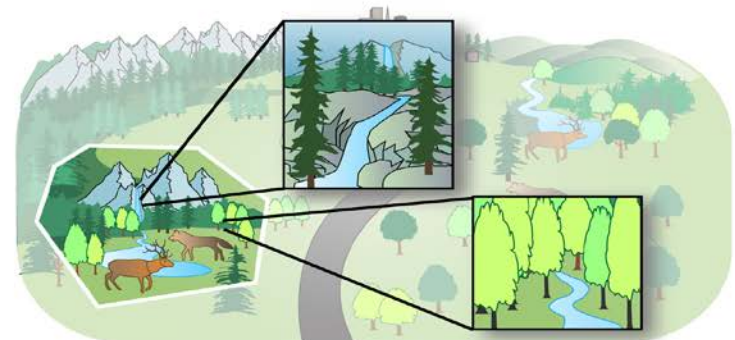


Protect the geophysical setting

## Anticipate and Respond to Future Conditions



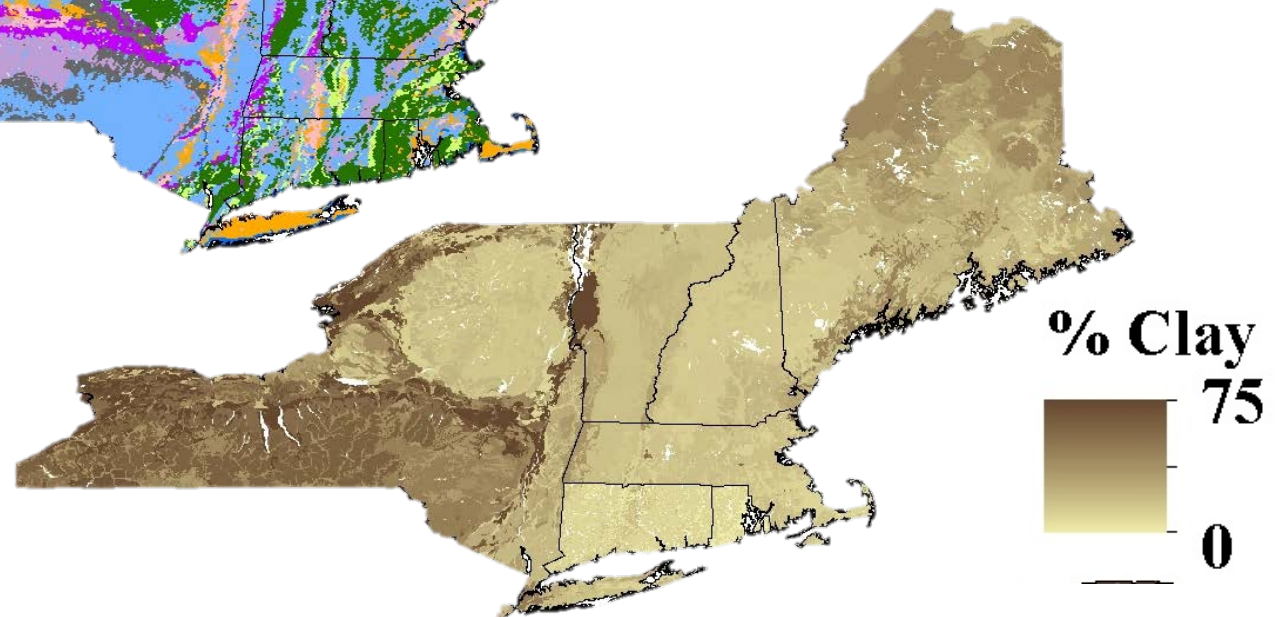
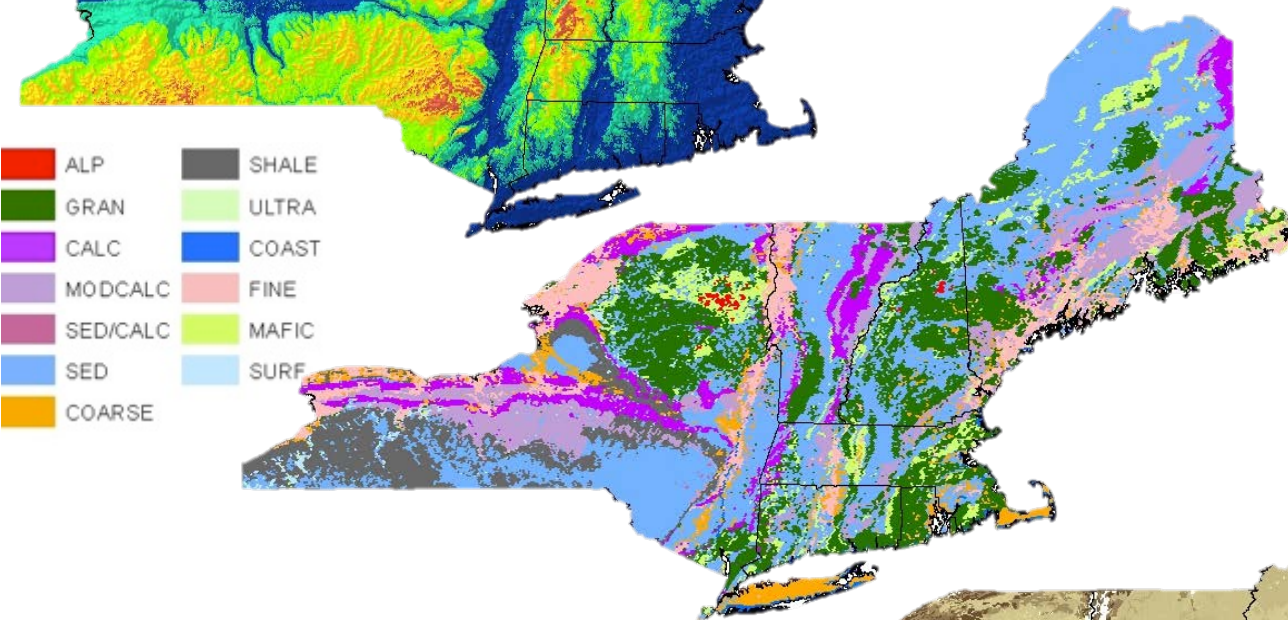
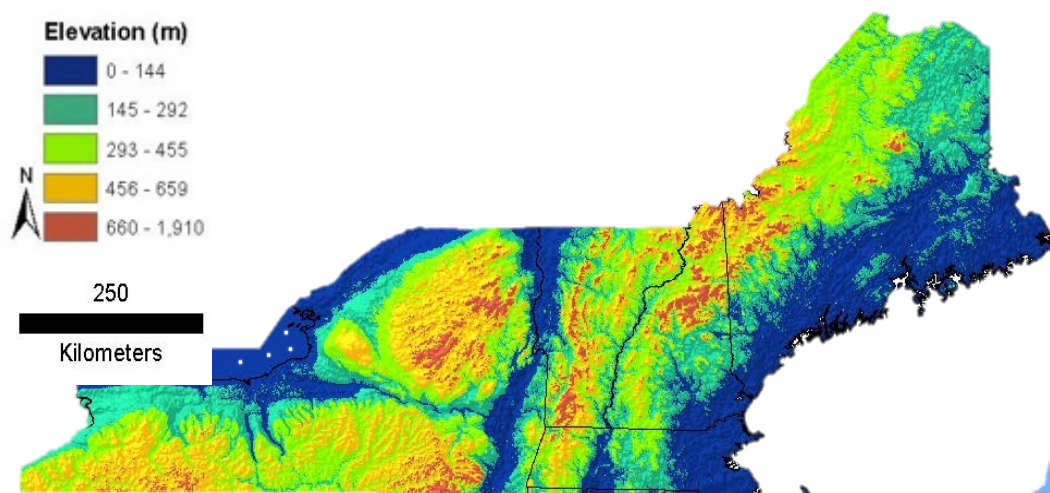
Identify and protect future climate space



Identify and protect climate refugia



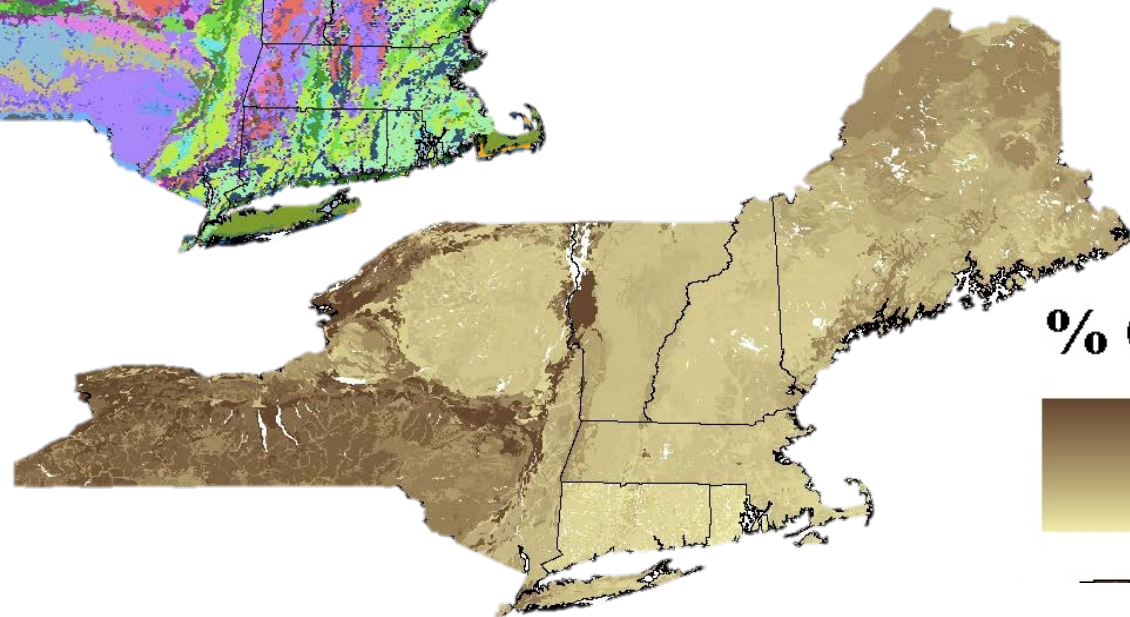
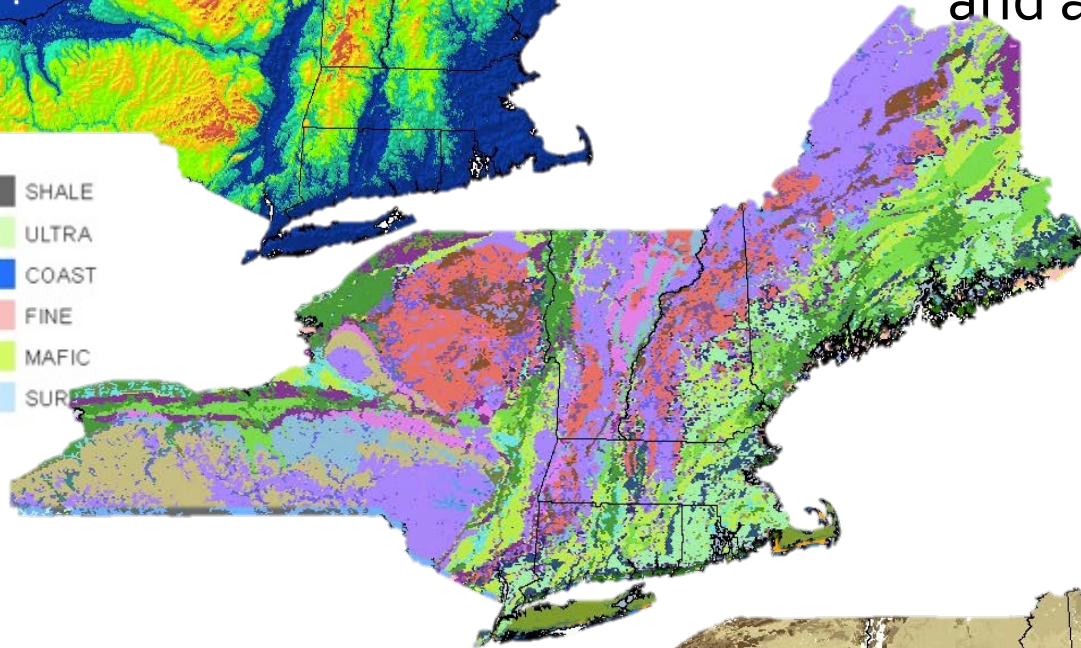
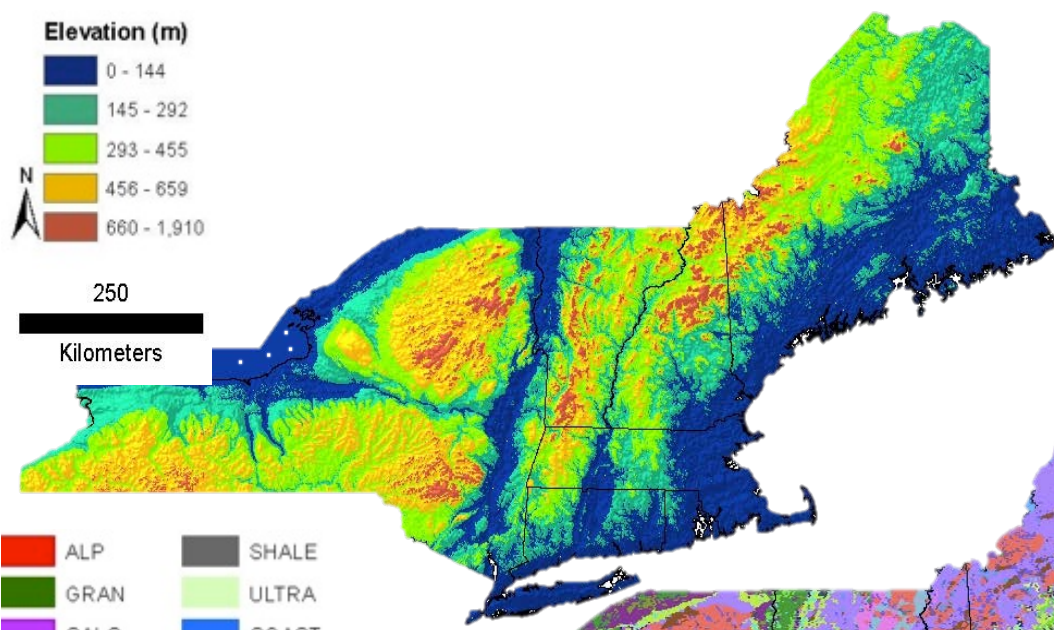
Maintain and establish ecological connectivity



Protecting a wide variety of Geophysical settings that remain relatively constant as climate changes & plants and animals shift.

Topography,  
Bedrock, &  
Surface Material





Protecting a wide variety of Geophysical settings that remain relatively constant as climate changes & plants and animals shift.

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Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Current biodiversity			
2) Natural landscapes			
3) Geophysical setting			
B. Anticipating and responding to future conditions			
4) Future Biodiversity.			
5) Climate refugia			
6) Ecological connectivity			

Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			USFWS, LCC
2) Protect large, intact, natural landscapes	State Wildlife, Local Agencies	USGS	
3) Protect the geophysical setting		Forest Service	
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.		BLM, USGS	National Park Service
5) Identify and protect climate refugia		USGS	
6) Maintain and restore ecological connectivity	USFWS, State Wildlife Agencies		

# Yale Framework

- Private Funders

Doris Duke Charitable Foundation, The Kresge Foundation, & Wilburforce Foundation

- Assessment to support decision making

- Panel experts convened

- Created structured Framework

- Review Process

- Pilot Projects

- Outreach



